

Notes on the biogeographical regions of Australia

by C. F. H. Jenkins

22 Freshwater Close, Claremont, W.A. 6010

Manuscript received 21 July 1981; accepted 13 October 1981

Abstract

Ever since Tate published his paper in 1887 on the biogeographical regions of Australia and designated the arid interior as the Eremian, zoologists and botanists have defined a wide range of regional zones resulting in an increasingly complicated system of nomenclature. A review of numerous papers indicates a general acceptance of the central arid region, but a diversity of views as to the number and demarcation of the peripheral zones. No evidence has been found to support the substitution of "Eremean" or "Eremaean" for Tate's original spelling "Eremian".

Introduction

Ever since Professor Ralph Tate (1887) presented his paper "On The Influence of Physiographic Changes in the Distribution of Life in Australia" and divided the continent into three major regions, biologists have questioned the legitimacy of the regional boundaries and the appropriateness of the nomenclature used. Tate (1887, p. 315) defined his regions as follows:

1. Euronotian (lit. south-east wind) dominant in the south and east parts of the Continent.
2. Autochthonian (lit. of the original race) restricted to the south-west corner of West Australia, and approximately co-inciding with the rain-fall limit of twenty inches.
3. Eremian (lit. desert) dominant in the dry region, which has its centre in the Lake Eyre Basin."

Hedley (1894) and Baldwin Spencer (1896) gave general support to Tate's regions, but Spencer divided the Euronotian into the Torresian (northern tropics) and the Bassian (cool south) subregions and used the word Eyrean (after Lake Eyre in South Australia) to include Tate's Eremian and Autochthonian Regions (Serventy and Whittell 1948).

Australia

As knowledge of animal and plant distribution increased it became clear that the early biogeographical regions did not fit all circumstances and that while certain basic subdivisions could accommodate most disciplines the exact lines of demarcation between the different areas and the numbers of subregions would depend largely upon the groups studied (McMichael and Iredale 1959). For instance Serventy and Whittell (1948) working on birds do not agree that South-western Australia as defined by Spencer is typically Eyrean and produce convincing evidence, confirmed by numerical computer analysis (Kikkawa and Pearse 1969), to show that the region is a blend of Eyrean and Bassian elements. Littlejohn (1967) working with frogs supported this view, but Tyler (1976,

p. 185) studying the same group saw no reason to modify Spencer's boundaries. However, he did acknowledge that "No scheme of provinces is going to satisfy all zoologists and the situation occurring in the south of the continent is a prime example of the problem that exists."

Key (1959, p. 207) working with grasshoppers stated "The distribution and taxonomic relationships of the Australian Acridoidea certainly suggest relative discontinuities in the vicinity of Spencer's boundaries. However, grasshoppers are more sensitive to the environment than Serventy and Whittell's birds (being poikilotherms of lower vagility), so that it is understandable that the significant ecological cliffs should be more numerous..."

Whitley (1959) recognised nine subdivisions as appropriate to Australian freshwater fishes and stated that these are supported by other freshwater fauna, including tortoises, crustacea etc. His subdivisions are based mainly upon drainage systems and include a central Sturtian region (which includes much of the Eremian) and a northern Leichhardtian region which incorporates a large portion of Spencer's Torresian subdivision.

Sloane (1915) working on beetles recognised ten subdivisions, but another entomologist, Paramonov (1959) working with Diptera recognised only two major "subregions"—*Australica deserta* and *Australica sylvatica*, although he distinguished three subdivisions of *sylvatica*. McMichael and Iredale (1959) studying molluscs defined seven areas and Campbell (1943) working with birds described twelve separate zones.

Pianka (1969) specialising on lizards (*Ctenotus*) divided the central desert (Eremia) into 13 subdivisions or provinces and Doing (1970), by calling the Eremian the Central Australian Subkingdom and the remaining periphery the Eucalyptus Subkingdom, recalls Paramonov's two major subdivisions. However, Doing goes much further with his regions or provinces and recognises 25 subdivisions in all.

Although the lines of demarcation used in the different systems do not coincide there is basic acceptance of a large central desert region and a variable number of peripheral zones. Furthermore there is increasing support by zoologists for Whitley's (1959, p. 141) warning against regarding "our division of Australia into areas... as hard and fast outlines." Serventy and Whittell (1948, p. 47) studying birds have shown that "instead of thinking of fixed regions it is necessary to think of fluid faunas." The range of these faunas may expand or contract in response to geological and climatological changes and they are particularly sensitive to alterations in rainfall and vegetation types.

Western Australia

At the State level the study of biogeographical regions has received most attention in Western Australia and the earliest work was done by Mueller (1867) who stressed the specialised nature of the South-west flora. Diels (1906) recognised a South-west botanical province and the dry Eremaean (sic), and with some modifications this was supported by Gardner (1942), who divided the State into a South-west Province, a Northern Province (including the Pilbarra) and the Eremaea (sic).

Clarke (1926, p. 118) divided the State into 15 natural regions which "should be in harmony with the distribution of distinctive plant associations" and determined the subdivisions by the simultaneous consideration of topography, geology, rainfall and vegetation. Burbidge (1960) divided the continent into three "Principal Floristic Zones"—the Tropical, the Temperate and the Eremaean, but her major divisions differ little from those of most other workers and her treatment of Western Australia is in broad agreement with the earlier work of Gardner and Bennetts (1956).

Beard (1980) draws attention to the fact that regional maps of Australia suffered in the past from small scale and inadequate basic information, but adds that while preparing vegetation maps at the 1:1 000 000 scale covering the greater part of Western Australia he came to appreciate the reality of the "ecological regionalisation" of both Clarke and Gardner. Beard (1980, 1981) accepts the major provinces of Gardner (1942) and of Burbidge (1960), but divides the Eremaean into 11 districts and excludes much of the Pilbarra (Fortescue district) from the Northern Province. He makes certain other boundary adjustments based upon the increased topographical and botanical information now available from aerial photography and expresses the hope that "the system now becoming available... be of use to workers in other fields as well." (Beard 1980, p. 47).

It will be many years before the distribution of the major zoological groups has been mapped in the detail which now applies to vegetation. As a result of the "Bird Atlas" study now being conducted by the Royal Australasian Ornithologists' Union knowledge of bird distribution will be improved greatly in the near future, and it is to be hoped that this will not lead to a spate of new zoogeographic terms and boundaries. Already Davies (1979) writing on the breeding seasons of birds has introduced another element by adapting the subdivisions used by the

Commonwealth Bureau of Meteorology, but as may be expected these areas show important similarities with several other systems, including Spencer's (1896) and Clarke's (1926).

Discussion

The present review has shown that almost all specialists can produce plausible reasons to support an individual set of geographical subdivisions appropriate to their particular interests. On the other hand the wide acceptance of Spencer's major regions together with appropriate subregions could meet the main requirements of many biogeographers and reduce the confusion which now exists in this field.

However, Moore (1961) warns that in their efforts to delimit zoogeographical areas in Australia no one has set out a clear basis for recognising a zoogeographical region and although this is often assumed to be obvious it is not. He does not question the validity of the major zoogeographical divisions of the earth with Australia and some nearby islands as a single region. He sets out four criteria which may be used to test the validity of a zoogeographical region or subregion and these are summarised as follows:

1. A zoogeographical region must have boundaries which can be determined with a moderate degree of precision.
2. A zoogeographical region should have fauna markedly different from that of the adjacent zoogeographical region.
3. A significant proportion of the fauna of the zoogeographical region should have ranges approximately co-extensive with the region.
4. A zoogeographical region should be an area isolated at the present time or during its past for a sufficient period of time to have allowed the faunas to differentiate.

Moore also suggests that zoogeographical regions should have other attributes, if possible, such as applicability to many groups.

Using Moore's (1961) criteria "we can recognise a distinct zoogeographical region in the south-west, but the rest of the continent cannot be divided in any satisfactory manner." He contends that the wide support for the conventional zoogeographical regions in Australia "comes... more from the zoogeographers than from the fauna." The Australian frogs seem to support his views and he counters the argument that the details of distribution for many frogs are not yet known by claiming that "better data are required for establishing the reality of a zoogeographical region than for questioning its validity."

Nomenclature

Almost as much discussion has hinged around the nomenclature used for the various subdivisions as the demarcation of the actual boundaries. The terminology of Tate (1887) was not accepted by Spencer, who extended the Eremian to include Tate's Autochthonian and divided Tate's Euronotian into the northern Torresian and the southern Bassian. Nicholls (1933) criticised the term "Autochthonian" on the grounds that each area could have its own autochthonous elements and suggested the "Hesperonotian" (western) as more appropriate.

Paramonov (1959, p. 180) criticised such words as "Autochthonian" and "Euronotian" and said "the use of such terms only overburdens our minds with new words." He then added further to the confusion by suggesting two new subdivisions—Australica deserta for the arid centre (Eremian) and Australica sylvatica (wooded) for the periphery. This he divided further into Australica westralica, Australica bor-orientalis and Australica merorientalis.

The word Eremia, first used by Tate (1887) has aroused considerable discussion based upon its derivation and spelling. Diels (1906) gave no explanation for changing the spelling to Eremaea and this form was used by Burbidge (1960) and Beard (1980). However, Gardner (1942) used the spelling Eremaea, also without explanation and this form was retained by Gardner and Bennetts for their work on toxic plants in 1956. Tate's original spelling was used by Harrison (1926), Nicholls (1932) and Moore (1961) although most zoologists have avoided the issue by following Spencer's terminology and using the word Eyrean for the dry interior.

It has been suggested that Diel's use of the term Eremaea to replace Tate's earlier Eremia may have been based on Lindley's spelling of *Eremaea* for a genus in the family Myrtaceae. Another suggested explanation is that, as Webster's Third New International Dictionary defines Eremian as a division of the Palaearctic region, including the North African and Asiatic deserts, a different spelling should be used for comparable regions elsewhere. However, in the absence of any evidence to support these suggestions they carry little weight. There seems little doubt that the correct spelling is Eremia, as the word comes from the Greek meaning a solitude, a wilderness or a desert. It has given the English language the word hermit—a hermit and is the basis for several scientific names including *Eremiornis carteri* for the spinifex bird or Carter's desert-bird and *Eremianthus* for another genus of inland birds.

Conclusion

The current state of knowledge gives a fairly clear indication of why the boundaries of biogeographic regions do not meet the strict criteria proposed by Moore (1961). Indeed, it would be strange if it were so, because the biota is clearly of two origins with forms of each origin adapted to past climates, with the consequence that each worker will produce a different biogeographic classification depending on the component or components of the biota which he chooses to use. The biota closely adapted to broad climatic factors clearly yields a classification like that of Baldwin Spencer, while one which recognised the original components of the biota would clearly recognise Autochthonian regions. Future biogeographic studies need to recognise that different groups of plants and animals have different capacities to handle climatic fluctuations, and hence their distribution will reflect this. Moreover, the old and newer components of the biota may be restricted in terms of climate or minor habitats, and it would seem to be reasonable for future workers to try and unravel the likely past history of the group or groups being used in biogeographic studies, so that the assumptions about the suitability of the group for distinguishing biogeographic boundaries become explicit.

References

- Beard, J. S. (1980).—A new phytogeographical Map of Western Australia. *Western Australian Herbarium Research Notes* 3:37-58.
- Beard, J. S. (1981).—The history of the phytogeographic region concept in Australia, in *Ecological biogeography of Australia*, A. Keast (ed.), p. 337-353. Dr. W. Junk-Den Haag.
- Burbidge, N. T. (1960).—The phytogeography of the Australian Region. *Aust. Jour. Bot.*, 8: 75-211.
- Campbell, A. G. (1943).—Australian Faunal Regions. *Emu*, 4: 242-243.
- Clarke, E. de C. (1926).—Natural Regions in Western Australia. *Jour. Roy. Soc. W.A.*, 12: 117-132.
- Clarke, E. de C., Prider, R. T. and Teichert, C. (1971).—*Elements of geology for Western Australian students*. Univ. of W.A. Press, Nedlands.
- Common, I. F. B. and Waterhouse, D. G. (1972).—*Butterflies of Australia*. Angus & Robertson, Sydney.
- Crocker, R. L. (1959).—Past climatic fluctuations and their influence upon Australian vegetation, in *Biogeography and ecology in Australia*, p. 283-290, Dr. W. Junk-Den Haag.
- Davies, S. J. J. (1979).—The breeding seasons of birds in South-western Australia. *Jour. Roy. Soc. W.A.*, 62: 53-64.
- Diels, L. (1906).—*Die Pflanzenwelt von West-Australien südlich des Wendekreises*. Vegetation der Erde 7, Leipzig.
- Doing, H. (1970).—*Botanical Geography and Chorology in Australia*. Misc. papers 6, Landbouwhogeschool, Wageningen.
- Gardner, C. A. (1942).—The Vegetation of Western Australia with Special reference to climate and soils. *Jour. Roy. Soc. W.A.*, 28: 11-87.
- Gardner, C. A. and Bennetts, H. W. (1956).—*The toxic plants of Western Australia*. W.A. Newspapers, Perth.
- Hedley, C. (1894).—The Faunal Regions of Australia. *Rpt. Australasian Assoc. Adv. Sci.*, 5: 44-46.
- Harrison, L. (1926).—The composition and origins of the Australian fauna with special reference to the Wegener hypothesis. *Rpt. Australasian Assoc. Adv. Sci.*, 18: 332-396.
- Iredale, T. and Whitley, G. P. (1938).—Fluvial fauna of Australia. *South Aust. Nat.*, 18: 64-68.
- Key, K. H. L. (1959).—The ecology and biogeography of Australian grasshoppers and locusts, in *Biogeography and ecology of Australia*, p. 192-208, Dr. W. Junk-Den Haag.
- Kikkawa, J. and Pearse, K. (1969).—Geographical distribution of land birds in Australia—a numerical analysis. *Aust. Jour. Zool.*, 17: 821-840.
- Littlejohn, M. J. (1967).—Patterns of Zoogeography and speciation in south-eastern Australian Amphibia, in *Australian inland waters and their fauna*, A. H. Weatherley (ed), p. 158-174. Aust. Univ. Press, Canberra.
- McMichael, D. F. and Iredale, T. (1959).—The land and freshwater Mollusca of Australia, in *Biogeography and Ecology of Australia*, p. 224-244, Dr. W. Junk-Den Haag.
- Moore, J. A. (1961).—The frogs of eastern New South Wales. *Bull. American Mus. Nat. Hist.*, 121: 153-385.
- Mueller, F. (1867).—Australian vegetation. *Intercolonial Exhibition-Essays*, 251-269.
- Nicholls, G. E. (1933).—The composition and biogeographical relations of Western Australia. *Rpt. Australasian Assoc. Adv. Sci.*, 21: 93-138.
- Paramonov, S. J. (1959).—Zoogeographical aspects of the Australian diptero-fauna, in *Biogeography and Ecology of Australia*, p. 164-191, Dr. W. Junk-Den Haag.
- Pianka, E. R. (1969).—Sympatry of Desert Lizards in Western Australia. *Ecology*, 50: 102-130.
- Serventy, D. L. (1973).—Origin and structure of Australian bird Faunas, in *Birds of Australia* by J. D. McDonald, p. 21-28, Reed, Sydney.

- Serventy, D. L. and Whittell, H. W. (1948).—*Birds of Western Australia*, p. 46-47, Paterson Brokensha, Perth.
- Sloane, T. G. (1915).—On the Faunal Subregions of Australia. *Proc. Roy. Soc. Vict.*, **28**: 130.
- Spencer, Baldwin (1896).—Summary of the Zoological Results, in *Report on the work of the Horn Expedition to Central Australia*. Vol. I.
- Tate, R. (1887).—On the influence of physiographic changes in the distribution of life in Australia. *Rpt. Australasian Assoc. Adv. Sci.*, **1**: 312-325.
- Tyler, M. J. (1976).—*Frogs* p. 182-193, Collins (Aust.) Ltd.
- Whitley, G. P. (1959).—The freshwater fishes of Australia, in *Biogeography and Ecology in Australia* p. 136-148, Dr. W. Junk-Den Haag.